MANITOBA/CANADA CONSERVATION AND RENEWABLE ENERGY DEMONSTRATION AGREEMENT

The availability of secure and affordable energy supplies is a subject of national concern. It is an accepted fact that our primary energy sources - oil and natural gas - are becoming less accessible and more costly. However, Canada is well-endowed with non-renewable and alternative resources that can provide a bridge into the future.

To this end, the governments of Manitoba and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement which was signed May 9, 1980 and terminates March 31, 1984. The Agreement is dedicated to the development and demonstration of conservation and renewable energy technologies. Equally cost-shared by the provincial and federal governments, the program has a total budget of $18-million.

The objectives of CREDA are:

- To develop and demonstrate promising new technologies, which, when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently.
- To develop broad public awareness of the potential of renewable energy and conservation technology.
- To provide opportunities for the commercial application of the technologies within Manitoba.
- To create economic spin-off benefits for manufacturing, industry and commerce.
- To create employment in new or existing energy-related industries.

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WINNIPEG, MANITOBA

April 1984

WINNIPEG ENERSCHOOL RETROFIT

W.L. Wardrop & Associates Ltd.
Winnipeg, Manitoba —
Consulting Engineers

SCHOOLS

Major Retrofit

Pierre Radisson Collegiate
St. Boniface School Division #4

Minor Retrofits

Avery School
Seven Oaks School Division #10

Guyot School
St. Boniface School Division #4

Prince Edward School
River East School Division #9

Springfield Jr. High
Transcona-Springfield School Division #12

Stevenson School
St. James-Assiniboia School Division #2

Transcona Collegiate
Transcona-Springfield School Division #12

Westview School
Transcona-Springfield School Division #12

RURAL ENERSCHOOL RETROFIT

Underwood McLellan Ltd.
Winnipeg, Manitoba —
Consulting Engineers

SCHOOLS

Berens River School
Frontier School Division #48
Berens River

Centennial School
Agassiz School Division #13
Lac du Bonnet

Erickson Collegiate
Rolling River School Division #39
Erickson

McCreary School
Turtle River School Division #32
McCreary

Minitonas School
Swan Valley School Division #35
Minitonas

Roseau Valley Collegiate
Boundary School Division #16
Dominion City

St. Joachim School
Seine River School Division #14
La Broquerie

Neelin School
Brandon School Division #40
Brandon

NORTHERN ENERSCHOOL RETROFIT

Scouten, Mitchell, Sigurdson & Associates Ltd.
Winnipeg, Manitoba —
Consulting Engineers

SCHOOLS

Major Retrofit —

Brochet School
Frontier School Division #48
Brochet

Minor Retrofits —

Leaf Rapids School
Leaf Rapids School District #2460

Ruth Betts School
Flin Flon School Division #46
Flin Flon

Scott Bateman Jr. High
Kelsey School Division #45
The Pas

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In 1983, the Governments of Manitoba and Canada initiated the School Retrofit Program; Enerschool. Technical and financial assistance was provided for testing and demonstrating various energy conservation techniques in a number of schools throughout Manitoba. Eight urban, eight rural and four northern facilities were chosen to participate, with the intent that the selected locations would provide a representative cross-section of similar facilities nation-wide. The schools selected were divided into two groups; minor and major retrofits. Major retrofits included a capital cost retrofit allowance of $4.40/sq.ft whereas the minor retrofit schools had a cost allowance of $0.33/sq.ft. The major retrofit schools were located in Brochet, in Manitoba's northern region and in Winnipeg. The minor retrofit schools were located in southern Manitoba at Winnipeg, Berens River, Beasejour, Erickson, McCreary, Minitonas, Dominion City, and Brandon. Northern sites included schools at Leaf Rapids, Flin Fon and The Pas. The installation phases of the projects will be completed in 1984, when monitoring and evaluation will begin.

This manual is based on the conclusions of studies performed on the various school facilities included in the program.

Enerschool funding is provided under the Manitoba/Canada Conservation and Renewable Energy Demonstraton Agreement (CREDA). CREDA provides two-thirds of all project costs. The balance was assumed by the respective participating school divisions.

The Enerschool Steering Committee was responsible for program administration. This included representatives from Manitoba Energy and Mines; Energy, Mines and Resources Canada, the Manitoba Association of School Trustees, the Public Schools Finance Board and Manitoba Education.

This manual is intended to serve as an information handbook for the school administrator, maintenance manager, or power engineer who is attempting to reduce facility energy consumption and costs. The intent is not to fully instruct the reader in all aspects of energy retrofitting, nor is it to train him or her as an energy auditor. Rather, the manual will discuss the energy performance of various facility systems pointing out areas where various energy saving measures or retrofits might be successfully applied. Many of these measures are simple and low cost, and can be implemented by school personnel. Others are more expensive and complex, and qualified professionals should be consulted. This manual will assist the reader in recognizing possible retrofit applications in the facility, and will explain how to implement the less involved measures. More complicated applications will be discussed in light of the reader seeking qualified assistance.

PART I discusses the general aspects of the energy conservation process, and PART II examines the operation of a school, pointing out specific areas and examples of applications.

To effectively reduce the energy bills of an entire school division, all staff should actively participate in the energy conservation process.

At the School Board level, the school trustees must be enthusiastic proponents of energy conservation, helping to initiate programs in their schools. The Board will naturally decide how funds are to be proportioned. As such, the potential energy savings should provide the incentive for Board members to allocate funding to an energy conservation program.

The building administrator and the active program director must ensure that sufficient time can be devoted to implementing the program effectively.

The program director - whether the Principal or the Principal's assistant, the power engineer, or the head of custodial staff - should have a basic understanding of mechanical and electrical systems as well as building structure. Armed with this knowledge, he or she should be prepared to initiate a well organized energy conservation program for the entire school system.

Though not as actively involved, custodians, office staff and teaching staff should realize that their active support will contribute to the success of the program.

Initiating an energy conservation program should follow these steps:

1. Ask senior administrative personnel for their commitment to the program. Commitment and visible involvement at the senior level will encourage involvement by all levels of staff.

2. Select or elect one person to be the program director, responsible for the management of the program and reporting directly to the senior administration. Make sure that the individual is prepared to devote sufficient time to administering the program.

3. Set program goals in a clear-cut format. Make sure that the goals set are realistic, specific and measurable. A goal which is vague or provides no means of measurement will quickly discourage staff. Calculated or estimated values, in addition to reference values from similar programs or published recommendations from technical societies, can be used as a guide in setting goals.

4. Efficiently plan the program. Use the following six steps as a guideline when planning your program:

i) Undertake an energy audit, employing knowledgeable staff, the Energy Bus or an independent consultant. The audit should define the facility's anticipated energy consumption and compare it with actual consumption. The audit is essential to identify areas where energy is being lost or wasted, and to provide a yardstick to measure the effectiveness of energy conservation measures.

ii) Start the program with quickly obtainable savings. Something in the order of 5 percent saved in six months is a reasonable goal. This will allow the implementation of low cost modifications without greatly depleting the school's budget. Meeting achievable goals will also maintain enthusiasm among the staff members.

iii) Regular review of the programs will encourage the involvement of members and will promote greater acceptance of the program and understanding of the goals.

iv) Evaluate previously set goals to ensure that they are realistic and attainable, and establish new goals to maintain the program's momentum.

v) Invite feedback, not only from the building staff, but also from the teachers and students. Inviting comments can improve the relationship and morale of participants. As well, posting information and exchanging ideas with the staff and other schools and school divisions will contribute to the success of the program.

vi) Submit periodic progress reports to the senior administration and Board of Directors, highlighting the progress and results to date. Maintaining program visibility will facilitate continued funding and support.

Guidelines for the school system are:

- Communications and a staff awareness program will ensure a smooth transition to energy efficiency.

- Commitment by the individual is valuable in convincing others of the importance of a successfully implemented program.

- With staff cooperation, a successful energy conservation program will reduce energy costs and permit the reallocation of budget dollars to other areas - areas that will benefit the staff and the students alike.

Throughout the school term, the school building uses several forms of energy. If the building is supplied with natural gas or electricity, it is not possible to "see" this energy arriving at the building, or being consumed, yet the energy bills arrive without fail. Even though we cannot always "see" energy arriving or leaving, we know that the total amount of energy purchased is consumed or lost in the building. First, let's look at the form in which energy arrives and how it is billed.

1. Energy In

Energy is usually purchased from four main sources: natural gas, propane, fuel oil and electricity. Refer to Figure 1 for a comparison of energy costs.

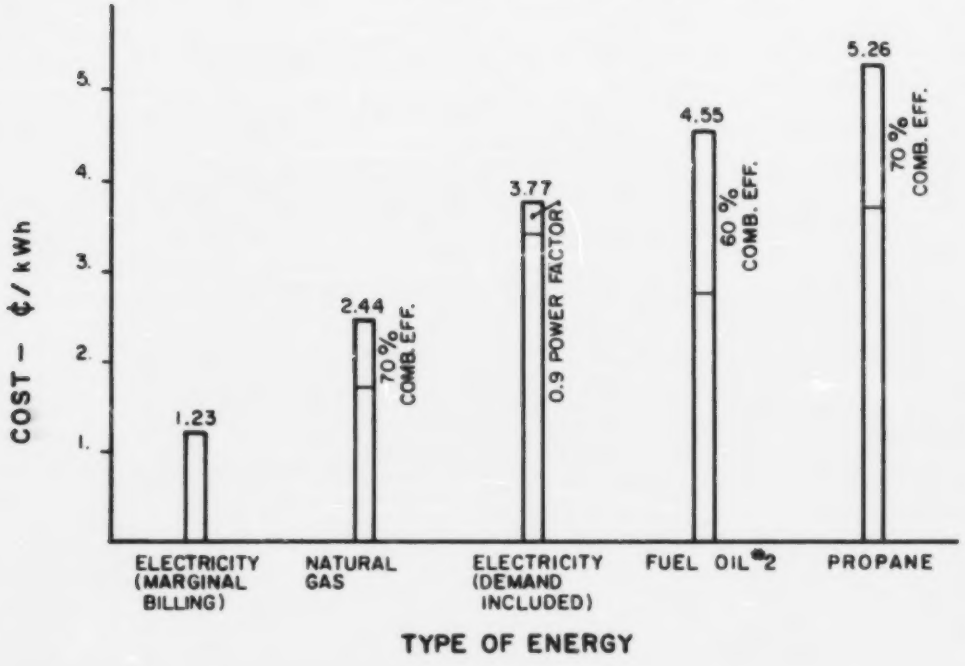

FIGURE 1
COMPARISON OF ENERGY COST

Natural Gas and Propane:

Natural gas is purchased on a cost per unit volume basis - usually MCF (1000 cubic feet), CCF (100 cubic feet), or cubic meter. Propane is purchased per litre or gallon. One MCF of natural gas produced about 1 000 000 Btu (293 kWh), and one gallon of propane will produce 110 000 Btu (32.2 kWh). Typical combustion efficiencies for furnace and boiler applications range from 60 to 80 percent, depending upon the age and type of equipment. The efficiency figures represent that portion of energy from the gas which is transferred to the heating medium. The balance of the energy is lost up the chimney as hot air and combustion byproducts.

Fuel Oil:

Fuel oil is also purchased per unit of volume - usually in gallons or litres. Energy content averages 145 000 Btu (42.5 kWh) per gallon, and efficiencies range from 50 to 70 percent.

Electricity:

Electricity is purchased on a per kWh basis. In addition, a charge may be assessed based on how much electricity is consumed at any given time. This is called demand, and it is measured in kilo-volt amperes, or kVA. Demand is charged because the electrical utility must

maintain equipment capacity to meet the peak loading demand of its customers. This is illustrated in Figure 2.

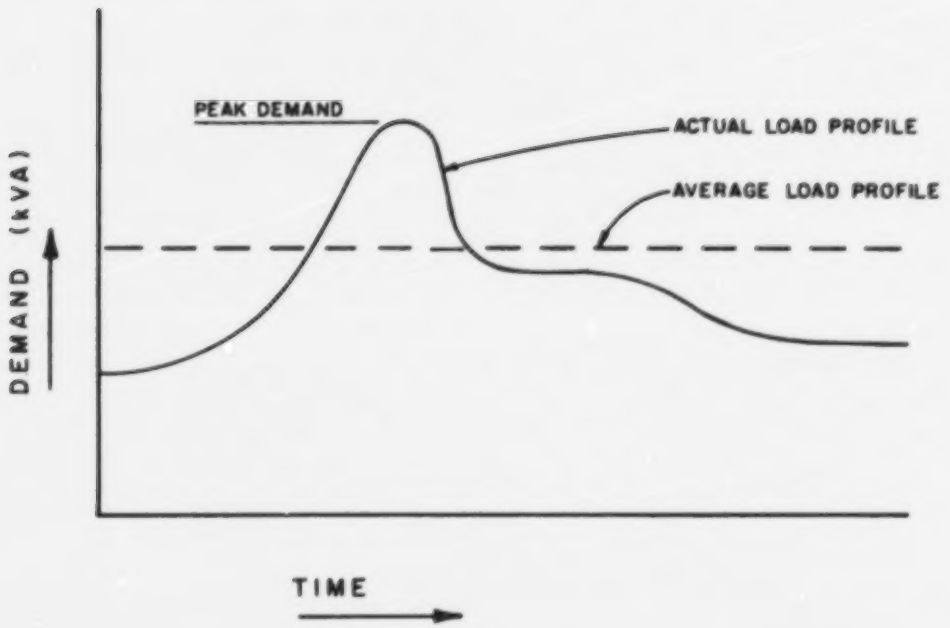

FIGURE 2
ILLUSTRATION OF PEAK DEMAND

The area under the solid line represents the actual energy consumed, while the dotted line represents the same energy at a continuous demand. Note that the solid line rises and surpasses the dotted line for a short period of time. Although the average energy consumption of both systems are identical, the solid line system has a very high energy demand for a short period of time. This is the peak loading demand. Peak loading usually

occurs in the winter months, and a large excess of utility capacity is idle the rest of the year. This is why demand is charged year-round based on a percentage of the previous recorded winter peak. To accommodate this billing structure, most electrical meters record both kWh consumption and peak kVA demand.

2. Energy Out

Now, let's take a look at where the energy is going.

Fuel combustion energy is consumed as follows:

- As heat lost up the chimney of boilers and furnaces due to combustion inefficiency and heat exchanger design.

- As heat that escapes from uninsulated ducts or pipes. This energy is often not utilized in the occupied space and is lost to unoccupied spaces, crawlspaces and eventually the outside.

- As heat added to the school rooms to offset transmission losses through walls, roofs and windows.

- As heat added to raise the temperature of infiltration air.

- As heat added to the make-up air to raise its temperature to be compatible with the

surrounding room temperature.

- As heat added to the domestic hot water, which after its use leaves the building envelope through the sanitary drainage system.

Electrical energy is used in the following ways:

- To provide light.
- To generate heat through inefficiencies in transformers, motors and lighting fixtures.
- To operate business machines, audio systems, etc.
- To operate machinery for moving air, pumping liquid, compressing gases, etc.
- In the classrooms, labs and shops, electrical energy may be converted to motion or heat by the use of demonstration equipment, saws, lathes, sanders, ovens, heaters, etc.
- In some schools, the energy is used directly for school heating.
- In air-conditioned schools, electrical energy is utilized to operate the refrigeration equipment.

Although these energy use patterns are noted individually, they are often closely related. For instance, lighting equipment contributes to the heating of the school. The conversion of a lighting system to a more efficient type will be somewhat offset by the requirement to add heat from other sources. This is one example of how closely the various energy forms in a school are related. This interrelationship must be assessed when energy conservation measures are being developed.

With a consideration for the relationship of energy forms, it is possible to reduce the net loss of energy in a school. This can be accomplished either by plugging the "holes" through which energy escapes, or by reducing the energy input to provide the same or equivalent results. It is not the intent of an energy conservation program to reduce the comfort level for staff and students. Rather, it is intended to more efficiently use the energy available to provide comfortable conditions, adequate lighting and air quality conducive to an effective educational environment.

With the previous sections in mind, we can examine the financial analyses necessary for the acceptance or rejection of a proposed energy conservation measure.

The costs associated with the implementation of an energy conservation measure or retrofit are not necessarily limited to the capital cost of the retrofit. Often other factors come into play, such as the increased operating or maintenance costs associated with the retrofit.

Other factors can also interfere with the energy savings calculations. Often the savings resulting from an energy conservation measure are offset by the increased energy consumption in another area. In addition, savings from energy conservation retrofits are rarely additive. For instance, if the reduction of air flow in an exhaust fan saves $100 per year in natural gas while reduced operating hours of the fan saves $50 per year in electricity, then it only seems natural that the total annual savings will be $150. But this is not the case; the total will be <u>less</u> than $150.

But the simplest and most widely used method of financial assessment is the SIMPLE PAYBACK ANALYSIS, which neglects these other factors.

$$\text{SIMPLE PAYBACK} = \frac{\text{CAPITAL COST OF RETROFIT}}{\text{ANNUAL COST SAVINGS}}$$

The result of this equation is a term expressed in years. It represents the period of time it takes to recover or pay back the initial investment. The lower the figure, and the sooner the energy conservation measure pays for itself, the better.

Example

Assume that a contemplated energy conservation measure has a capital cost of $1,000 and the estimated annual savings in energy costs is $250, then the PAYBACK period for this measure is:

$$\text{PAYBACK} = \frac{1000}{250} = 4 \text{ years}$$

Payback figures of under one year are very good; those between one and five years acceptable; and those greater than five marginal.

Monitoring plays a key role in the evaluation of a successful energy conservation program. Without monitoring there is no yardstick by which to judge the success of the program.

To develop an effective monitoring schedule, it is necessary to acquire energy bills from the last year or two. The consumption (and demand) figures from these bills should be transferred to a master form for record-keeping purposes. The form should include all energy bills from each source and tabulate them monthly. Samples of forms that could be used for this purpose are at the end of this section.

This will provide a strong basis for comparison of consumption before and after the implementation of energy conservation measures. As well, the establishment of annual energy consumption values can be ratioed through the gross floor area of the school to provide an Energy Index figure. This can be compared with other schools in the Enerschool Program and schools in your division. The index is calculated as follows:

$$\text{Energy Index} = \frac{\text{Annual Consumption (kw hours)}}{\text{Gross Floor Area (sq.ft.)}}$$

Example

Let's look at a school which has two sources of energy - natural gas and electricity. From the energy bills for a one year period, total the consumption figures for each source. When the one year period starts or ends does not matter, as long as the values are for 12 consecutive months. After this, you will have 2 totals, one expressed in kWhs and one in cubic meters or cubic feet. Let's say that the gas is purchased in units of 1000 cubic feet (MCF). Then the annual consumption of the two energy sources is:

Natural Gas	4,352 MCF
Electricity	328,200 kWh

Since these two figures are not expressed in the same units, they cannot be added directly, so we will convert the MCF to kWH by multiplying by a factor of 293 (refer to Section 3.2 for standard conversions). The two consumptions can now be expressed in the same units and totalled:

Natural gas	1,275,136 kWh
Electricity	328,200 kWh
Total	1,603,336 kWh

Now, with the total annual energy consumptions known, and the school building area measured as, let's say, 46,000 sq.ft., the building's energy index can be calculated as follows:

$$\text{Energy Index} = \frac{1{,}603{,}336 \text{ kWh}}{46{,}000 \text{ sq.ft.}} = 34.9 \text{ kWh/sq.ft.}$$

Table 1 lists the calculated energy index for the 20 Manitoba schools studied under the Enerschool Program.

To eliminate different weather conditions influencing annual consumption, obtain monthly meteorological data from Environment Canada in the form of monthly degree days. A degree day is the sum of the product of the number of hours below the established temperature of 18°C (65°F). If all figures for annual consumption are divided by annual degree days for that year, then each year can be compared on an equal basis independent of weather. In this way, a small increase in natural gas consumption during a cold winter but immediately after a retrofit, will not necessarily mean the retrofit is ineffective as an energy conservation measure.

In some cases, it may be advisable to take daily or hourly meter readings of energy consumption to establish load profile immediately before and after an energy conservation retrofit.

An additional benefit of record keeping is that easily overlooked problems can be identified quickly by regular surveillance of the records. When new readings are entered, they should immediately be compared to the figures from previous years. For instance, an unusual increase in natural gas consumption may indicate that a fresh air damper is sticking, or temperature set points have been tampered with.

TABLE 1

ENERGY INDICES FOR
SCHOOL IN ENERSCHOOL PROGRAM

School	School Size*	Region	Energy Index (kWh/sq.ft.)	Cost $/sq.ft.
1	Large	North	24	.72
2	Medium	North	24	.72
3	Medium	North	24	.69
4	Medium	North	38	1.17
5	Medium	Rural	43	1.21
6	Medium	Rural	35	.62
7	Medium	Rural	35	.58
8	Medium	Rural	31	1.06
9	Medium	Rural	45	2.57
10	Small	Rural	29	.85
11	Small	Rural	41	1.13
12	Small	Rural	46	1.30
13	Large	Winnipeg	49	1.02
14	Medium	Winnipeg	42	.79
15	Medium	Winnipeg	24	.47
16	Medium	Winnipeg	38	1.16
17	Medium	Winnipeg	21	.62
18	Medium	Winnipeg	45	.88
19	Medium	Winnipeg	34	.68
20	Medium	Winnipeg	51	1.32

* Less than 25,000 sq.ft. - Small
Between 25,000 and 75,000 - Medium
Greater than 75,000 - Large

Emphasis must be placed not only on keeping records active and updated, but also on maintaining a regular analysis of the values entered. In this way record-keeping evaluates the progress of the energy conservation program, highlights problem areas and acts as a comparison base with other schools and programs. Record keeping is intended to fulfill a purpose, not merely fill a form with numbers.

NATURAL GAS RECORD

		a	a x 293 = b	c	c/b
PERIOD ENDING	READING	CONSUMPTION M.C.F.	CONVERSION TO kW.h	TOTAL COST ($)	AVERAGE COST PER kW.h ($)

ELECTRICAL ENERGY RECORD

UTILITY RATE CODE: _____

PERIOD ENDING	READING	CONSUMPTION kW.h	DEMAND kVA		TOTAL COST ($)	AVERAGE COST PER kW.h ($)
			ACTUAL	BILLING		

WATER RECORD **UTILITY RATE CODE:**

PERIOD ENDING	READING	CONSUMPTION (CU FT)	COST ($)	AVERAGE COST PER CUBIC FOOT

PROPANE RECORD

		a	a x 7.1 = b	c	c/b
PERIOD ENDING	READING	CONSUMPTION LITRES	CONVERSION TO kW.h	TOTAL COST ($)	AVERAGE COST PER kW.h ($)

OIL RECORD

		a	a x 10.73 = b	c	c/b
PERIOD ENDING	READING	CONSUMPTION LITRES	CONVERSION TO kW.h	TOTAL COST ($)	AVERAGE COST PER kW.h ($)

The building envelope - that is, the walls, roof, windows and doors - isolates the classroom environment from temperature extremes, wind, rain, sun and sound. This manual is concerned with the thermal aspects of the envelope. Weaknesses or faults in the envelope can cause excessive thermal transmission losses or gains, unnecessary infiltration or exfiltration and ineffective solar heat gains. Energy losses can be reduced by improved maintenance procedures and implementation of improved energy conserving retrofit measures.

1. Maintenance

Consider the two following suggestions to reduce your school's energy consumption:

i) Inspect the weatherstripping and caulking on all entrance doors and operable windows. It is imperative for the weatherstripping to be in good condition, forming a complete seal between the door and door frame to prevent excessive air infiltration or exfiltration. This also applies to operable windows. If the weatherstripping is loose or damaged, it should be replaced with new material selected specifically for the application. It is especially important to select weatherstripping that can withstand the heavy use characteristic of school entranceways.

When selecting materials, the type of door and frame must also be considered. The selection of weatherstripping depends on the construction materials used in doors and windows. The most effective type of weatherstripping for school doors is a heavy duty closed cell neoprene foam gasket with an adjustable wood or metal backing strip. Adjustability is particularly important when the door is constructed of wood , since wood doors are subject to warpage. Non-adjustable weatherstripping installed on a door that warps can be virtually ineffective. Also, be sure to inspect and replace the threshhold seal on the bottom of the door.

Caulking the joints between door and window frames and the building wall, as well as at building construction joints, louvers, and duct and pipe penetrations prevents air infiltration or exfiltration through the wall. Inspect caulking on a regular basis, preferably in the spring and fall, and remove any loose or broken caulking from the joint. Recaulk with a good quality sealant.

Reducing the infiltration through doors, windows and cracks will reduce the load on the heating plant during the winter, since less cold air will enter the building and require heating.

Correspondingly, the summer cooling load will be lessened by reducing the amount of air which requires cooling.

ii) Another method of energy conservation involves the building's decorating and window cleaning schedule. In the classroom, clean, light coloured walls and ceilings reflect more light than dirty or dark surfaces. Clean light surfaces improve the illumination levels and reduces the need for artificial lighting. The selection of warm tones such as yellows, oranges and reds instead of cool tones like blues and greens can permit the reduction of room temperatures by up to one degree Fahrenheit without affecting those in the room.

Similarly, the transmission of solar energy in the form of infrared and visible light through a piece of glass is largely dependent on the cleanliness of the glass. The cleaner the glass, the more transmission and the less reflectance. In other words, the cleaner the windows, the more natural light and solar gain the interior will receive and the more positive the net energy balance will be.

2. Retrofits

i) In some schools, large expanses of glass have been installed in corridors, links, vestibules and courtyards. These are usually attractive features in a school but are not energy-efficient. It is possible to reduce the thermal transmission losses through these large expanses of glass by one of the two following methods:

a) Remove the existing glazing, leaving the glazing frame in place. Replace the glazing with an insulated wood or steel panel and finish the inside and outside with colours and material suitable to the location. This method of retrofitting is quite visible from both the inside and the outside, and the appearance may differ somewhat from the other building surfaces.

b) Remove the complete glazing and frame and reconstruct the wall with material to match the existing wall. If the existing wall is wood or metal stud construction, this may prove economical. If it is of concrete or masonry construction, the cost is likely to be prohibitive in relationship to the energy saved.

The improvement in the thermal insulation value available with the

wall replacement is about seven-fold. The normally accepted value for dual pane glazing is R2 (0.35RSI), but for the insulated wall can range from R12 to R20 (2.1 to 3.5RSI).

ii) The same approach can apply to smaller windows and glazing when the glazing is no longer required to provide natural light. This often happens in labs, storerooms and industrial shops where the windows are blocked with equipment, shelving, furniture, etc. In some cases it can even apply to the classroom. When this happens it is possible to add insulation to the window and close it off from the exterior. The procedure is simple. Insulation in the form of fibreglass batt, semi rigid or rigid insulation can be installed on the outside of the glass, then covered with a decorative board of wood, metal or vinyl. Trim colours should be selected to complement the existing wall finish.

In the same fashion as item 2, before, consideration must be given to the aesthetic value of the modified window before this procedure is implemented.

iii) Most schools have vestibules at the active entrances to buffer the infiltration of large quantities of outdoor air. The effectiveness of these vestibules should be checked by ensuring that the doors close properly, that they are not propped open, and that the door closures are in

working order. All outside doors should have automatic door closures.

If your school does not have a vestibule at the active entrance doors, consider adding an extra set of doors and a long enough air lock to prevent holding both doors open simultaneously.

iv) The last and probably most significant energy conservation measure is the upgrading of insulation levels in walls, roofs and ceilings. The first step is to assess the present condition of insulation and insulation levels of the existing structure. Then determine the potential for adding more insulation. In most cases it will be difficult, if not impossible, to add insulation to the wall structures. Adding insulation to the roof is also difficult, as well as costly. However, this is not always an impossible situation. There are many situations in which additional insulation can be installed to provide a realistic payback, such as:

a) Where the wall structure or facing requires repair, such as brick or mortar upgrading, wood siding replacement or repairs to damaged plaster or drywall. The installation of insulation at this time may prove economical.

b) When the built up roof is seriously aging, or requires extensive repair. Adding rigid insulation to the roof deck can be accomplished in various ways, but it depends more on the condition of the existing roof than on any other single factor. Some of the alternatives are:

- partially strip the existing roof and rebuild;
- completely strip the existing roof and rebuild; and
- leave the existing roof membrane intact and install an inverted roof system.

c) When the roof deck is accessible from inside the building, insulation can often be added for a reasonable cost. Loose insulation with the addition of binders can be sprayed against the underside of the steel deck in gymnasiums, auditoriums and even in classrooms with false ceilings. Insulation of this type, however, must be fireproof or treated with a fireproofing compound.

d) Where there is an attic space which can be readily accessed to allow for the installation of batt or blown insulation.

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A variety of heating and ventilating systems are used in schools today. A brief description of the function of heating, ventilating and air conditioning systems follows:

Heating systems provide temperature control by supplying energy which offsets the heat loss of the facility. The three basic types are air, hydronic, and electric. Air systems use furnace heated air as the energy-carrying medium. Hydronic systems rely on fluid, usually water, to transport heat to room convectors or fan-driven unit heaters. Boilers usually heat the fluid in these systems. Electric heating is usually comprised of resistance heaters located on the building perimeter.

Ventilation systems exhaust building air and supply fresh outdoor air. The purpose is to provide contaminant and humidity control. The ventilation incurs an energy cost because outside air must be heated or cooled before it can be introduced to the occupied spaces.

Air conditioning systems provide summer temperature control by extracting the heat from the facility and dispelling excess heat to the outside. The two basic types are air and water. Air systems use cold air at a central location as the heat absorbing medium. Water systems utilize chilled water from the refrigeration unit and transport the water to a remote fan coil unit, where the heat is absorbed.

1. Maintenance

Regular maintenance of heating, ventilating, and air conditioning equipment is essential for operating efficiency, as well as reduced energy consumption. The following list of preventative measures should be carried out regularly to help maintain equipment at its peak operating efficiency.

i) Inspect combustion chamber refactory for deterioration, cracks and leaks, then repair as required. Deterioration of the fire brick will cause heat to escape from the combustion chamber and be wasted in the boiler room.

ii) Check steam traps for leakage and repair or replace as required. Steam traps usually vent steam into the condensate system and waste it to the atmosphere.

iii) Check condensate tank vents for visible plume of steam which indicates leaking traps as described above.

Check packing glands, valves and joints for leaks and repair as necessary. Steam or water leaking from piping systems not only raises energy costs, but water treatment costs as well.

Check operation of pressure reducing and regulating valves and adjust, repair, or replace as necessary. Pressure reducing

or relief valves that malfunction can prevent proper temperature control in a classroom or can waste water and energy to the building's drainage system.

iv) When operating equipment, check drive belts for wear and tension and replace or adjust as necessary. Badly worn or loose drive belts can cause excessive friction, severely affecting the life of the belts, as well as contributing to inefficient power transmission and increased energy consumption.

v) Lubricate operating equipment such as motors, fans, compressors, etc. Follow manufacturer's recommendations where applicable and be cautious not to overlubricate.

vi) Maintain all inlet or outlet screens on air handling unit, make-up air units and exhaust fans. In addition, maintain the cleanliness of air system filters and electrostatic air cleaners. Do not allow the differential filter pressure to exceed the manufacturer's recommended maximum pressure drop loading.

vii) Inspect air system ductwork on a regular basis for broken joints or damaged flexible connectors. Excessive leakage in the air system will result in less effective heating or cooling and may

adversely affect control system operation.

viii) Ensure that pipe and duct insulation is continuous. Repair loose, damaged or missing sections. Poor insulation continuity causes uncontrolled energy losses to the surrounding environment.

ix) Inspect dampers on outdoor air to ensure that damper blade operation is correct, that the damper blade closes properly and that the blade seals are in satisfactory condition. A damper blade that does not close properly or has damaged or missing blade seals can cause excessive air infiltration through the damper when the air systems are not operating.

x) Employ the services of a furnace or boiler serviceman to undertake combustion analysis of the flue gas. Combustion analysis provides a good indication of the efficiency of the furnace or boiler. An improperly adjusted heating unit uses excessive fuel to provide the specified output.

xi) Inspect and clean strainers on hot water, steam and condensate lines. Dirty strainers are similar to air filters. When they are loaded, their pressure drop increases causing excessive energy consumption in the circulating system.

xii) Inspect the heat exchanger components of boilers and furnaces regularly and remove loose deposits of soot and scale. These combustion deposits reduce heat transfer from the combustion gases and overall efficiency of the heating unit.

2. Conversion To Alternate Energy Sources

Rising energy prices makes it imperative for school operators to compare the current prices of all energy forms to ensure using the most economical. To compare different fuels it is necessary to develop a cost for kilowatt per BTU and divide by the estimated combustion efficiency of the fuel.

It is necessary to know the cost per unit volumes, the energy content of that volume and the seasonal combustion efficiency of the equipment. Comparisons, of course, must be done on an equal basis. The cost per unit for electrical energy may vary from month to month and between schools since it depends a great extent upon the demand load profile.

If a facility is not using the most economical heating source, a qualified engineer or heating contractor should be consulted. Heating loads and installation costs will determine if conversion is advisable. Even if complete conversion is not an economical alternative, partial conversion to an alternate energy source may be viable,

depending upon the current demand profile and service capability. Combination heating usually means electric heat displacing oil or gas during periods when the electrical demand is below peak. During this period of time, electrical costs are calculated for consumption only at the marginal billing rate, exclusive of demand. Figure 1 in Section 1.2 illustrates this point very well. The marginal cost of electricity is almost half of the cost of natural gas and less than a third that of oil. Of course, it will be necessary to automatically limit the electrical heating to off-peak hours and utilize the existing fuel to maintain building requirements during electrical peak.

3. Scheduling Equipment

This energy conservation measure basically involves turning off equipment and reducing temperatures and systems' run times during unoccupied hours. Scheduling equipment can be accomplished in the following ways:

i) Reduce thermostat setpoints in heated areas during unoccupied hours - night, weekends and holidays. This is known as setback. Setback saves energy because of less thermal transmission through the building due to the temperature difference between outside and inside. Systems using combustion fuels such as natural gas, propane and oil can be

setback as low as 55°F (13°C). Systems that utilize electric baseboard heating should be restricted to a minimum temperature of 65°F (18°C) to avoid incurring high demand cost when the thermostats return to the occupied settings. The electric heating system can be setback further if a way can be devised to stage the return to the occupied setting. Setback of thermostats in smaller schools can be accomplished manually by appointing one or two people to adjust thermostats at the end of each day. For larger schools this is impractical; instead installing automatic setback controls should be considered. Setback programs typically provide heating cost reduction of 5-10%, depending upon the after-hours use of the facility and the type of building construction.

ii) Shut down all ventilation systems during unoccupied hours unless the system is required to provide space heating. In this case, override the mixed air controls to shut down the outdoor air intake damper and operate the ventilation system with complete return air. This will reduce the need to heat the entering outside air. In the same fashion, shut down all exhaust fans not required during unoccupied hours. The energy savings will be the same because for each unit

volume of air expelled to the outside by the exhaust fans, the same unit of air must be drawn into the building from the outside. This air, like that introduced through the ventilation system, must also be heated to room temperature. Since most ventilation systems operate in unison with exhaust fans, the above modifications compliment each other but do not necessarily provide double the savings.

iii) Whenever possible, use the least number of heating boilers that will meet the load. Boiler efficiency increases with increased duty cycle.

iv) Equipment that is periodically out of use should be turned off at the electrical panel to prevent accidental operation.

v) Ventilation systems in gymnasiums should be equipped with manual reset timers with a 0-1 hour range so that the instructor can set the operation according to occupancy. The manual reset timer should be selected without a "hold" feature.

vi) When destratification fans are located at the ceiling, ensure that they operate continuously day and night throughout the heating season. During winter, the fans will reduce the temperature of the room

at the ceiling and will be beneficial even during unoccupied hours.

4. Temperature Control

Temperature controls play an important part in the school's energy consuming, heating, ventilating and air conditioning systems. A single thermostat maladjusted or out of calibration can cause unnecessary heating or cooling, resulting in excessive energy consumption.

The following are suggestions related to adjusting, calibrating or modifying temperature control systems to reduce energy consuption by heating, ventilating and air conditioning equipment. Since control systems vary almost as much as the systems themselves, it is unlikely that all of the following points will pertain to any one school.

i) Coordinate heating and cooling system operation by regularly checking thermostat setpoints. Heating and cooling equipment should never be allowed to run simultaneously. Equipment that is controlled by room thermostats should have the thermostat set at 75°F (24°C) or higher for cooling and 70°F (21°C) or lower for heating. It is also possible

to provide interlock wiring to the cooling equipment to stop it operating when the heating system is on or when the outdoor temperature is not warm enough for interior cooling.

ii) Ensure proper control of outdoor air quantities in mixed air plenums. In this system the quantity of outdoor air is determined by the temperature setpoint of the mixed air controller. The normal setpoint for this type of control is 55°F (13°C). Resetting this setpoint to 60°F (15°C) will reduce the outdoor quantity and reduce the quantity of heating required in the air system. Some systems are also provided with a minimum position adjustment to maintain a fixed minimum quantity of outdoor air. It is usually possible to adjust the setting on this dial to reduce the quantity of outdoor air to be heated or cooled. In making this adjustment, ensure that the Provincial Code requirements for ventilation air are followed.

iii) Ensure that outdoor dampers and mixed air systems are operating properly and that damper linkages are correctly adjusted so

that positive control of outdoor air quantities can be achieved. Do not disconnect and close off outdoor air intakes since this may contravene Provincial Regulations and will not allow the system to operate in free cooling mode during the intermediate season.

iv) Systems that utilize uncontrolled backdraft dampers or relief hoods should be modified to incorporate tight closing automatic control dampers. These dampers should be regulated from the mixed air controller of the associated fan systems. This will prevent excessive exfiltration or infiltration of outdoor air during times when the fan system is not operating.

v) As mentioned, existing thermostats should be modified or new thermostats installed to provide temperature setback operation during unoccupied hours. An alternate approach is to shut down the heating system from a centrally located control valve and install one or two night setback thermostats in the corridors to cycle the complete heating system at a lower temperature. When the system

returns to its occupied cycle, control of room temperatures reverts to individual room thermostats.

vi) Ensure temperature controls are in good condition. A temperature control system that is out of calibration or operating incorrectly can cause excessive energy consumption. In many cases, this consumption may go unnoticed for a period of time.

vii) To determine whether or not control systems are operating properly, consider installing temperature gauges on air handling systems to monitor return air, outdoor air, mixed air, and supply air temperatures. If these temperatures are recorded regularly, it will be easier to identify the operating sequences of the temperature control system.

viii) Ensure all people involved in the maintenance of the air and water systems understand the function of various temperature control systems. A general understanding of the operation of the systems will help identify problems when they occur and enable corrective action to be taken promptly.

ix) Provide seasonal temperature reset on water and air systems. This energy conserving measure will correspond the temperature setpoints of water and air supply systems more closely to the natural heating or cooling load of the school. The outdoor reset control can be used to modulate the hot water heating medium temperature, the mixed air temperature of air handling systems, or the discharge temperature of chilled water heating medium. The reduction of hot water heating medium temperature during spring and fall provides better control of space temperatures and reduces energy loss from piping systems. Control of the mixed air system on air handling units can provide greater degrees of free cooling during the cooling season to reduce air conditioning requirements. The reset of chilled water can improve the efficiency of the refrigeration unit, requiring less energy to produce equivalent results.

In addition to the previous suggestions on the temperature control system, the following recommendation is also applicable to most schools. Often it is possible to reduce the

air quantities circulated by the air handling system and still provide adequate ventilation and room temperature. Reduced air flows can contribute to energy savings by reducing horsepower requirements of the fan motor, lowering outdoor air volumes, and reducing bearing friction losses. In addition, it is conceivable that the life of air filters and rotating equipment can be extended, reducing maintainance and repair costs.

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There are usually two types of water systems in a school building. These are the domestic hot and cold water and the heating medium water system. Schools that are air conditioned often have a third type of system, called the chilled water circulating system. This section will deal with the domestic water system, as the heating and cooling medium waters have already been discussed under Section 2.2 Heating, Ventilating and Air Conditioning.

1. Maintenance

Maintenance of the domestic water system, like the heating and cooling water systems, is very important. Although the domestic water system is relatively simple, the following preventative maintenance measures should be considered.

i) Check the temperature setpoints on water storage tanks on a regular basis to ensure there has been no tampering.

ii) Inspect the faucets at all sinks including lavatories, janitors' closets and kitchens to ensure that the valves close drip tight. Attend to faucets which do not shut off completely.

iii) Clean strainers and drain water storage tanks on a regular basis to reduce pressure drops through piping systems and

prevent buildup of scale on heat exchanger surfaces.

iv) Just as reducing indoor temperature reduces building heat loss, lowering domestic hot water temperature will reduce heat loss from the tank and piping. Temperature reductions to 104°F (40°C) is a no-cost measure, and may reduce water heating costs by as much as 10%. Factors which affect the actual realization of this saving are:

a) The reduction in hot water temperature usually results in a slight increase in hot water consumption.

b) During the heating season the losses from tanks and piping contribute to the building heating. If the heat loss from the domestic hot water system is reduced by the temperature reduction, the heating system will be required to operate longer to make up the additional load. The impact of this difference will depend on the location of the storage tanks and piping in respect to the occupied heating zone. Of course, during the air conditioning season, the reduced thermal losses from tanks and piping will result in cooling load reduction.

c) This measure is beneficial to the natural gas and propane-fired hot water systems since the lower temperature setpoint reduces the frequency of burner cycling. This results in improved burner efficiency.

d) In some schools the hot water temperature is kept relatively high to provide the necessary wash water for dishwashing equipment. It may, however, still prove economical to reduce the hot water storage temperature and install a local electric booster heater for the dishwashing equipment alone.

2. Scheduling Equipment

Certain aspects of the domestic hot water system can be scheduled. As follows are a few suggestions:

i) Install a time clock to shut down the recirculation pumps during unoccupied hours. This will not only reduce the electrical energy input to the system, but will also reduce the thermal losses in the hot water piping system.

ii) Install time clocks and solenoid valves on automatic urinal flushing systems to allow flushing only during occupied hours. It is not expected that this item will save a large quantity of energy but it will reduce the consumption of cold water.

iii) In schools that are equipped with a dishwasher that has an electric auxiliary heater install a time clock or a local switch to shut the heater off during unoccupied hours. It is only necessary that the heater operate for a short period of time prior to and during the dishwashing cycle. This measure will reduce electrical consumption.

3. Retrofits

Other measures that can be undertaken to reduce energy consumption in the domestic water system are:

i) Install low flow shower heads in change rooms to reduce the quantity of hot water consumption during showering. This item can result in a 40% reduction in the energy consumption of showering hot water.

ii) Install insulation on all hot water storage tanks and hot water piping that is accessible. Reduction of heat losses

to the ambient air will result in reduced water heater operation and consequently reduced energy consumption.

iii) Install flow restrictors on all faucets in washrooms and kitchens to reduce water and energy consumption.

iv) Install self-closing faucets on all washroom sinks to prevent the faucet from running, which wastes water and energy.

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This section deals primarily with lighting systems but also discusses the efficient use of electrical energy from the standpoints of consumption and demand billing.

1. Maintenance

Common to all buildings, the maintenance of the electrical system will ensure the most efficient use of electricity. Suggested ways to monitor electrical component efficencies are as follows:

i) Establish a regular cleaning schedule for the lenses and lamps of lighting fixtures. Maintaining the lamps and reflectors in a clean condition will improve the illumination levels in the classrooms and corridors and may allow the use of lower wattage "watt-saver" lamps. Cleaning lamps and fixtures may not directly save energy in classrooms with single light switches. However, in schoolrooms with double switching for two-level lighting, it may permit use of low level lighting while providing more comfortable illumination levels.

ii) Check illumination levels in classrooms, labs, shops, and gymnasiums on a regular basis to ensure that lighting levels meet today's standards and that fixtures are clean.

When relamping fluorescent fixtures, consider the use of lower wattage "watt-saver" fluorescent tubes. These tubes use less energy with only minor reduction in light output.

iv) When replacing ballasts on fluorescent fixtures, select efficient ballasts with high power factor ratings.

v) When replacing complete fixtures, consider the benefits of the high efficiency lighting systems.

vi) To ensure that lamps are replaced with bulbs or tubes of the proper wattage, use plastic label tape on or beside the fixture to indicate the proper replacement item.

2. Switching and Scheduling of Lights

Efficient scheduling and switching of lighting systems prevents unnecessary energy consumption. Suggested guidelines are:

i) Turn off lighting in storage rooms, washrooms and equipment rooms when not in use. Reminder labels on switches are helpful.

ii) Use natural lighting as much as possible in lobby and foyer areas. Ensure that lighting in this area during the day is off unless excessive contrasts are

apparent when entering the building. A lobby or foyer area which is dark relative to the outside can create a safety hazard.

iii) Illuminate only building areas required for activity. Cleaning or maintenance personnel should work in one area at a time during the unoccupied hours.

iv) Ensure that outdoor lighting is off during the day by installing timers or photocell controls.

v) Scheduled control of operating mechanical equipment was discussed under the two previous sections, 2.2 Heating, Ventilating and Air Conditioning and 2.3 Water Systems.

vi) It is often practical to provide scheduled control of parking lot plugs. The preferred system of control not only reduces consumption by 50% but also reduces the peak demand loading. The system consists of a time clock, an outdoor thermostat and a contactor or set of contactors in association with the electric distribution panel. The optimum control scheme is as follows: above an outdoor temperature of -5 to -10°C as determined by the outdoor air thermostat, the parking lot plugs are disabled completely. Below the setpoint of the

outdoor air temperature controller, the plugs are cycled on and off at 15 minute intervals. Demand charges can only be saved if sections of the parking lot can be segregated and cycled alternatively. The feasibility of this installation depends a great extent on the lot size and usage and the electrical distribution network.

3. Load Shedding (Demand Control)

As discussed in Section 1.2 Energy Balance, electrical demand charges are assessed on the basis of monthly peak load. One kilowatt of load will register at least 1 kVa of demand. The objective of demand limiting is to minimize the peak demand by eliminating the number of electrial components which operate simultaneously.

Demand limiting is accomplished by the installation of automatic controls and interlocks on the various electrical loads. A qualified engineer or controls contractor should be consulted for demand control, as it requires a thorough analysis of the demand profile and building operations to determine the feasibility of load shedding and which loads are most likely candidates for control. In schools with partial or full electric heat, load shedding may be very attractive. Although a load shedding controller reduces the demand charges on the electrical utility

bill, it does not necessarily reduce consumption.

Two suggestions for reducing demand charges are:

i) Some central refrigeration units in air conditioned schools have factory-installed demand limit selectors on their control panels. Set the demand limit selector to the lowest possible setting, which allows the system to maintain the necessary space temperature. However, make sure that it always remains at that setting, or else demand limits may be exceeded.

ii) Associated with load shedding and demand control is the utilization of electrical power during off peak demand periods. In fact, the kilowatt hour "balance" charge or marginal rate, is often very inexpensive in comparison to the consumption rate of other energy sources.

Demand is charged on the monthly peak. Therefore, if a fixed load such as the air conditioning compressors combined with lighting and other power loads register regularly minimum demand, then any other load operating under that peak will not incur additional demand charges. It is effectively operating at the marginal rate. Of course, the multiple loads could not operate simultaneously,

making selective switching or demand limiting controls necessary to provide marginal rate of the non-essential load.

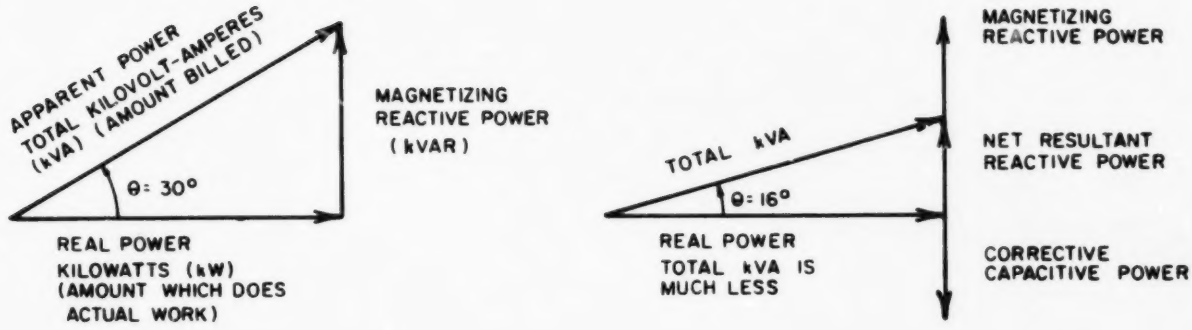
Systems normally using combustion fuels should be evaluated for partial or complete conversion to marginal rate operation. A typical and usually cost effective application is off-peak electric water heating. Payback will depend greatly upon the price difference between the marginal electric rate and the combustion fuel price.

4. Power Factor Correction

Mechanical equipment in the school is usually driven by electric motors. Transformers, induction motors, or other electromagnetic devices must be magnetized to function. The current which accomplishes magnetization is called reactive current, and does not produce any useable or "real" power and hence does not do any real work such as air moving or fluid pumping. Reactive current is a component of the total current which the machine draws, and total current can be thought of as producing total "apparent" power. The other component of the "apparent" power is the "real" power which is what performs the actual work. The ratio of real power (kW) to apparent power (kVA) is the power factor. Since the electrical demand charge is based on kVA, it

is desirable to keep the power factor as close to 1.0 as possible. The power factor of a system is either lagging or leading, depending on whether the reactive current is inductive or capacitive. Since most common motors and transformers produce a lagging power factor, the circuit can be corrected by connecting capacitors to the system.

Figures 3A and 3B are power factor diagrams before and after the addition of capacitors. In Figure 3A, the length of the Real Power line is 87% of the Apparent Power length and the power factor is 87%. In Figure 3B, after the addition of capacitors, the Apparent Power line is much shorter, and the power factor is 96%. This means the recorded demand is only 4% higher than the power actually used.



A UNCORRECTED B CORRECTED

FIGURE 3
POWER FACTOR CORRECTION

The general technique for specific power factor correction is to install capacitors at each motor location. A qualified engineer can size and price the necessary equipment. Local electrical utilities may also assist with this measure.

5. Lighting

Lighting is available in a number of system designs, with varying degrees of efficiency, colour quality and cost. Table 2 lists the major type of lighting sources available and summarizes their characteristics.

Lighting design is a complex subject, and any major installation or retrofit project should be undertaken with the assistance of a qualified engineer or architect. However, a number of items which can be assessed at the school level are:

i) Delamping should be carried out on a selective basis where lighting is excessive for the type of work occurring. Refer to Table 3 which lists recommended illumination levels for different tasks. Be sure to maintain the uniformity of illumination levels so as to prevent hot spots or dark spots within an area.

TABLE 2

LIGHT SOURCE CHARACTERISTICS

Source	Wattage	Ballast Wattage	Initial Lumens	Approx. Final Lumens Reduction	Rated Lamp Life (Hrs.)	Colour Quality	Lumens/ Watt	Comments
Incandescent	300	-	6 000	10%	1 000	Very Good	20	good switching
	500	-	9 900	10%	1 000		20	and low temp.
	1 000	-	23 740	10%	1 000		24	performance
Fluorescent	40 CW*	8	3 150	20%	20 000	Good	65	output falls
	40 CW*	8	3 200	20%	20 000		66	with temp.
	75 CW	15	6 300	20%	12 000		70	(70% at 30°F)
Mercury	250	35	12 000	35%-45%	24 000	Fair	42	good low temp.
	400	50	22 500	35%-45%	24 000		50	performance, 10-20 minute start-up
Metal Halide	175	40	14 000	25%-30%	7 500	Good	65	good low temp.
	400	50	34 000	25%-30%	15 000		76	performance, 5-10 minute start-up
High Pressure Sodium	100	16	9 500	10%	20 000	Fair	82	good low temp.
	250	53	26 600	10%	24 000		88	performance, low
	400	75	50 000	10%	24 000		105	start-up time

* CW - Cool White

* WW - Warm White

TABLE 3

ILLUMINATING ENGINEERING SOCIETY

RECOMMENDED LIGHTING LEVELS

AREA OR TASK	MINIMUM MAINTAINED LEVEL	
	FOOTCANDLES	LUX *
SCHOOLS:		
Corridors, Stairways	20	220
AUDITORIUMS:		
Assembly Only	15	160
Used for Lectures	70	750
TOILETS AND WASHROOMS	30	320
GYMNASIUMS:		
General Exercising	30	320
Exhibition Games	50	540
CAFETERIAS	50	540
CLASSROOMS:		
Classroom Work Study Halls, Libraries	70	750
Manual Arts, Drafting, Shops, Sewing Rooms, etc.	100	1100
CHALKBOARDS:		
(Supplementary Lighting	100	1100

* 1 Footcandle = 10.76 Lux

When delamping fluorescent fixtures, be sure to disconnect the ballast to prevent ballast operation and reduce energy consumption. When delamping 4-lamp fluorescent fixtures, it may be possible to rearrange the tube wiring to provide even lighting through the lens. In lieu of this capability, phantom tubes should be installed to provide even light distribution within the fixture.

Delamping has become a controversial topic in recent years. This controversy arises because all lighting equipment dissipates heat to one degree or another. Incandescent light bulbs, for example, dissipate most of their energy in heat and the remainder in light. In contast, high intensity discharge lighting such as low pressure sodium produces much of its energy as light with heat as the balance. Consequently, delamping an area primarily lit by incandescent fixtures will remove heat, thereby causing the heating system to operate longer to satisfy the heating requirement of the space. However, this concept is only applicable during the major portion of the heating season. During spring, summer and fall, the heat dissipated from the lighting equipment is

not required and is wasted. In air conditioned schools, the lighting equipment heat causes higher loading of the air conditioning system.

ii) Upgrade lighting systems by converting to more efficient lighting fixtures. The conversion to efficient fixtures will reduce electrical consumption and demand charges for the lighting system as a whole. As discussed in Delamping, the actual savings achieved in converting to higher efficiency lighting will be subject to the heating effect of the light fixtures. It is recommended that large areas utilizing incandescent fixtures be relamped with fluorescent type lights. If gymnasiums or auditoriums are utilizing incandescent fixtures, replacing them with high intensity discharge sources should be considered.

If outside lighting is utilized throughout the night to discourage vandalism, then incandescent flood lights could be replaced with a HID light, complete with photocell control. If exterior building lighting is only

utilized for a few hours in the evening during extracurricular activities, then this option may not be viable.

Table 4, Lamp Substitution guide, provides some examples of the saving available when changing to more efficient lamps.

6. Consolidate Electrical Meters
(On Demand Billed Services Only)

For a number of reasons, many facilities are serviced by more than one electrical meter. Since both meters may record peak demand, charges may be unnecessarily incurred by the recording of two peaks occurring at different times. For example, if two 70 kVA loads operate from different meters, they will register a 70 kVA demand on each one. If these two loads were on the same meter and operated at different times, then a single 70 kVA demand would be registered and charged on the single meter.

Of course, the savings resulting from this measure will depend entirely on what particular loads are operating simultaneously. However, the laws of probability favour consolidation to a single meter, and a

TABLE 4

LAMP SUBSTITUTION GUIDE

This chart gives you examples of savings achievable by substituting lamps or, in some cases, retrofitting for lamp substitution. Lamp manufacturers can provide you with more comprehensive lists of possible substitutions.

Now Using	Change to	Illumination Provided	Watts Saved	Power Savings Per Lamp*
40 watt fluorescent	34 watt fluorescent	approx. same	6	$ 2.25
40 watt incandescent	34 watt incandescent	approx. same	6	.30
	22 watt screw-in fluorescent	more	18	10.80
60 watt incandescent	22 watt screw-in fluorescent	same or more	38	22.80
75 watt incandescent	27 watt screw fluorescent	slightly less	48	18.80
75 watt par 38	55 watt par 38	approx. same	20	3.00
75 watt R30 Flood	50 watt ellipsoidal reflector	same or more	25	2.50
100 watt incandescent	90 watt incandescent	approx. same	10	1.75
	75 watt reflector	up to 25% more	25	6.25
	60 watt reflector	same or more	40	12.00
	40 watt screw-in fluorescent	approx. same	56	21.00
150 watt R-40 Flood	100 watt par 38 Flood	up to 133% more	50	12.50
	90 watt ellipsoidal reflector	up to 56% more	60	15.00
(R) 250 watt mercury	215 watt high pressure sodium	up to 130% more	35	21.00
(R) 400 watt mercury	325 watt metal haldide	up to 40% more	70	52.50
(R) 1000 watt mercury	880 watt high pressure sodium	up to 440% more	120	72.50

* Savings based on $.05 per KWH over rated lamp life. Actual savings will vary depending upon electrical consumption and demand rates, as well as frequency of use during peak demand periods.

(R) Indicates Retrofit

conservative demand reduction estimate would be 10%. The loss of the free first "X" kVA in most electrical rate structures is not significant since it is offset by the declining kWh schedule.

Occasionally multiple meter installations in smaller facilities are billed on General Service Rates, and record consumption only. In this case, consolidation will produce savings because the higher priced, initial "X" kWh blocks will be assessed on one meter instead of several.

In all cases, consolidation will result in the removal of extra meter service charges. This option is recommended if the building electrical systems allow relatively low cost consolidation or if any large scale demand limiting measures are to be implemented.

1. British Thermal Units (B.T.U.): the heat required to raise the temperature of one pound of water one degree Fahrenheit.

2. Footcandle: the unit of illumination taken on a surface area of one square foot receiving a uniformly distributed flux of one lumen.

3. I.E.S.: Illuminating Engineering Society.

4. Kilowatt-hour (kW.h): the amount of electrical energy produced by a 1 kW source in 1 hour.

5. Lumen: the unit of luminous flux generated through a unit solid angle by a uniform point source of one candela.

6. R-Value: resistance to heat flow, or the reciprocal of "C" - amount of heat transmitted through one square foot of a stated thickness of homogenous material in one hour when a temperature difference of 1°F exists between the two surfaces of the material.

7. Reflectance: the ratio of the reflected flux (light) to the incident flux.

8. Watt: the rate at which energy is expended by a current of 1 ampere under a potential of 1 volt.

Fuel Value Conversions

Fuel Oil #1	=	10.44 kWh/L
#2	=	10.81 "
Propane	=	6.86 "
Natural Gas	=	10.33 kwh/m^3
		29.27 kwh/mcf
		292.70 kwh/ncf